# Texas Natural Resource Conservation Commission
INTEROFFICE MEMORANDUM

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**Subject:**   Adjustment to March 6, 1997 Protective Concentrations in Groundwater for
               Construction Worker Exposure to Account for Time-Averaged Exposure

Representatives from the membership of the Texas Mid-Continent Oil and Gas Association
(TMOGA) have evaluated the methodology employed in the March 6, 1997 Interoffice Memorandum
(IOM) entitled *Clarifications and Amendments for Implementation of RG-36* to calculate
groundwater concentrations protective for dermal contact and inhalation of volatile emissions by
construction workers.  The methodology used in the March 6, 1997 IOM assumes a constant
concentration of the chemical of concern (COC) in the pit water over the exposure period.  TMOGA
contends that the use of a constant pit water concentration significantly overestimates intake via the
dermal and inhalation exposure pathways.  To more appropriately estimate intake, TMOGA
recommends the use of time-averaged COC concentrations in the pit water to estimate intake.  For
volatile COCs, the rate of volatilization from the pit water is likely much greater than the rate
groundwater flow resupplies COCs  to the pit water.  Therefore, the concentration of volatile COCs
in the pit water should be expected to decrease over the exposure period.

In response to and after technical evaluation of the TMOGA recommendation, the methodology to
determine groundwater concentrations protective for construction worker exposure will now be
based  on  time-averaged concentrations.  New  target groundwater concentrations for construction
worker exposure are presented in Table 1 and should now be used in lieu of the  target groundwater
concentrations presented in Table 4 of the March 6, 1997 IOM.  These new pre-calculated target
groundwater concentrations may be adjusted with the substitution of  site-specific information for the

default assumptions. The equations used to derive the time-averaged concentrations and all default assumptions upon which the amended concentrations are based are included as Attachment 1. All chemical properties presented in RG-36 were used if available, otherwise the chemical properties were taken from Attachment 2 which has been developed to support the new Texas Risk Reduction Program. In the application of these values, the cumulative risk/hazard index criteria specified in the March 6, 1997 IOM must still be achieved.

## Table 1. Target Groundwater Concentrations for Construction Worker Exposure[*]

| Constituent | Target Groundwater Concentrations (mg/l) | | | |
| --- | --- | --- | --- | --- |
| | Inhalation (mg/l) | Dermal (mg/l) | Combined Inhalation and Dermal (mg/l) | Target Concentration Based on Time Averaging (mg/l) |
| Acenapthene | ----- | 2.33e-01 | 2.33e-01 | **6.30e-01** |
| Acetone | ----- | 6.02e+02 | 6.02e+02 | **1.06e+03** |
| Anthracene | ----- | 3.24e+00[s] | 3.24e+00[s] | **1.41e+01[s]** |
| Benzene | 5.98e+00 | 8.01e+00 | 3.42e+00 | **2.01e+01** |
| Benzo(a)anthracene | 3.21e+01 | 1.11e-03 | 1.11e-03 | **1.14e-03** |
| Benzo(b)fluoranthene | 5.81e+00 | 5.05e-04 | 5.05e-04 | **5.80e-04** |
| Benzo(k)fluoranthene | 7.72e+03 | 5.05e-03 | 5.05e-03 | **5.05e-03[s]** |
| Benzo(a)pyrene | 6.69e+00 | 5.05e-05 | 5.05e-05 | **5.10e-05** |
| Chrysene | 5.72e+03 | 1.12e-01 | 1.12e-01 | **1.13e-01[s]** |
| Dibenz(a,h)anthracene | 9.43e+01 | 2.32e-05 | 2.32e-05 | **2.32e-05** |
| Dichloro(1,2)benzene | 1.09e+01 | 4.44e+00 | 3.16e+00 | **1.44e+01** |
| Dichloro(1,3)benzene | ----- | 4.39e+00 | 4.39e+00 | **2.09e+01** |
| Dichloro(1,4)benzene | ----- | 2.40e+01 | 2.40e+01 | **1.09e+02** |
| Ethylbenzene | 5.35e+01 | 4.97e+00 | 4.55e+00 | **2.17e+01** |
| Fluoranthene | ----- | 6.07e-02 | 6.07e-02 | **6.67e-02** |
| Flourene | ----- | 6.81e-01 | 6.81e-01 | **1.55e+00** |
| Formaldehyde[F] | 2.17e+02 | 3.30e+02 | ----- | **2.28e+02** |
| Indeno(1,2,3-cd)pyrene | 1.04e+03 | 2.30e-04 | 2.30e-04 | **2.30e-04** |
| Methyl Ethyl Ketone | 1.78e+02 | 1.90e+03 | 1.63e+02 | **3.02e+02** |
| Naphthalene | ----- | 1.92e+00 | 1.92e+00 | **8.35e+00** |
| Pyrene | ----- | 4.55e-02 | 4.55e-02 | **4.89e-02** |
| Toluene | 2.00e+01 | 1.91e+01 | 9.76e+00 | **4.88e+01** |
| Xylene | 3.53e+01 | 9.09e+01 | 2.54e+01 | **1.27e+02** |

* Target concentrations are based on a Hazard Quotient of 1 for noncarcinogens and a risk level of $10^{6}$ for Class A and B carcinogens, and a risk level of $10^{5}$ for Class C carcinogens.

s Denotes target concentration exceeds pure component solubility limit.

F  Formaldehyde has a non-carcinogenic RfD for dermal effects and carcinogenic SF for inhalation effects.  Therefore, inhalation and dermal exposure are evaluated as independent pathways.  The target concentration for formaldehyde is based on  inhalation exposure as it is the more protective concentration.

**Please note that for some compounds the target concentrations may be below analytical detection limits, and are therefore not measureable for purposes of demonstrating conformance with the target concentrations.  In these situations, the method PQL will suffice.**

**Attachment A:**

To calculate the target groundwater concentration based on time-averaged exposure:

**Step 1:** Determine the protective groundwater concentration for dermal contact and inhalation of volatiles emissions in accordance with the methodology prescribed in the March 6, 1997 IOM. (However, if no inhalation slope factor ($SF_i$) or inhalation reference dose ($RfD_i$) are available for the COC, then exposure should only be based on dermal contact). (Pre-calculated values are provided in Table B).

**Step 2:** Determine the average concentration of the pit water using the equation presented in Table A. Chemical factors and pre-calculated values are provided in Table B and are presented in Table B.

**Step 3:** Divide the average concentration $C_{avg}$ determined in Step 2 by the initial concentration $C_o$ ($C_{avg}/C_o$). For simplicity, an initial concentration of 1 mg/l may be assumed.

**Step 4:** Divide the groundwater concentration determined in Step 1 by the ratio $C_{avg}/C_o$ determined in Step 3 to yield a time-averaged protective groundwater concentration.

Table A

| | | |
|---|---|---|
| $$C_{avg} = C_o/a\tau[b\tau + (b/a - 1)(e^{-a\tau}-1)$$ <br><br> where: <br><br> $$a = ([K_{wa}/d] + [3D_{wat}/wL] + [D_{wat}/dL] + [Ki/w]), \text{ and}$$ <br><br> $$b = ([Ki/w] + [3D_{wat}/wL] + [D_{wat}/dL])$$ | | |
| Parameter | Definition | Default Value |
| $C_{avg}$ | Average dissolved COC concentration over time $\tau$ (mg/l) | chemical specific |
| $C_o$ | Initial dissolved COC concentration (mg/l) | 1.0 |
| $\tau$ | Exposure interval (3 weeks) (s) | $1.81 \times 10^6$ |
| $K_{wa}$ | Overall mass transfer coefficient (m/s)[1] | chemical specific (see Table B) |
| d | Depth of water in pit (m) | 1 |
| $D_{wat}$ | Diffusion coefficient in water (cm$^2$/s) | chemical specific |
| w | width of excavation (cm) | 470 |
| L | Characteristic length for diffusion (assumed equivalent to 1 foot) (cm) | 30.48 |
| K | Hydraulic conductivity (cm/s) | [2]$1.7 \times 10^{-4}$ |
| i | Hydraulic gradient (m/m) | [2]0.025 |
| [1] This parameter was denoted as "K" in the March 6, 1997 IOM. <br> [2](75th percentile value from Bureau of Economic Geology study, (Mace and others, 1997)) | | |

## Table B. Factors for Time-Averaging Equation and Diffusion in Air Coefficients

| Constituent | $D_{air}$ (cm²/s) | $D_{wat}$ (cm²/s) | $K_{wa}$ * (m/s) | a (/s) | b (/s) | $C_{avg}$ (mg/l) | $C_{avg}/C_o$ |
|---|---|---|---|---|---|---|---|
| Acenapthene | 6.95e-02 | 7.69e-06 | 1.36e-06 | 1.37e-06 | 1.32e-08 | 0.37 | 0.37 |
| Acetone | 1.09e-01 | 1.14e-05 | 6.88e-07 | 7.04e-07 | 1.52e-08 | 0.57 | 0.57 |
| Anthracene | 5.68e-02 | 7.74e-06 | 2.39e-06 | 2.40e-06 | 1.32e-08 | 0.23 | 0.23 |
| Benzene | 9.33e-02 | 1.10e-05 | 3.25e-06 | 3.27e-06 | 1.50e-08 | 0.17 | 0.17 |
| Benzo(a)anthracene | 5.10e-02 | 9.80e-06 | 2.89e-08 | 4.32e-08 | 1.43e-08 | 0.97 | 0.97 |
| Benzo(b)fluoranthene | 2.26e-02 | 5.56e-06 | 1.60e-07 | 1.72e-07 | 1.20e-08 | 0.87 | 0.87 |
| Benzo(k)fluoranthene | 2.26e-06 | 5.56e-06 | 1.20e-09 | 1.32e-08 | 1.20e-08 | 1.00 | 1.00 |
| Benzo(a)pyrene | 4.30e-02 | 9.00e-06 | 1.39e-08 | 2.77e-08 | 1.39e-08 | 0.99 | 0.99 |
| Chrysene | 2.48e-02 | 6.21e-06 | 1.62e-08 | 2.86e-08 | 1.24e-08 | 0.99 | 0.99 |
| Dibenz(a,h)anthracene | 2.00e-02 | 5.18e-06 | 9.83e-10 | 1.28e-08 | 1.18e-08 | 1.00 | 1.00 |
| Dichloro(1,2)benzene | 6.88e-02 | 7.90e-06 | 2.53e-06 | 2.55e-06 | 1.33e-08 | 0.22 | 0.22 |
| Dichloro(1,3)benzene | 6.88e-02 | 8.13e-06 | 2.63e-06 | 2.64e-06 | 1.34e-08 | 0.21 | 0.21 |
| Dichloro(1,4)benzene | 6.88e-02 | 7.90e-06 | 2.57e-06 | 2.58e-06 | 1.33e-08 | 0.22 | 0.22 |
| Ethylbenzene | 7.48e-02 | 7.80e-06 | 2.59e-06 | 2.61e-06 | 1.32e-08 | 0.21 | 0.21 |
| Fluoranthene | 3.02e-02 | 6.35e-06 | 1.09e-07 | 1.22e-07 | 1.25e-08 | 0.91 | 0.91 |
| Flourene | 6.26e-02 | 7.88e-06 | 1.09e-06 | 1.10e-06 | 1.33e-08 | 0.44 | 0.44 |
| Formaldehyde | 1.80e-01 | 2.00e-05 | 5.72e-08 | 7.70e-08 | 1.98e-08 | 0.95 | 0.95 |
| Indeno(1,2,3-cd)pyrene | 1.90e-02 | 5.66e-06 | 8.91e-10 | 1.30e-08 | 1.21e-08 | 1.00 | 1.00 |
| Methyl Ethyl Ketone | 9.43e-02 | 9.80e-06 | 7.77e-07 | 7.91e-07 | 1.43e-08 | 0.54 | 0.54 |
| Naphthalene | 5.90e-02 | 7.50e-06 | 2.39e-06 | 2.40e-06 | 1.31e-08 | 0.23 | 0.23 |
| Pyrene | 2.72e-02 | 7.24e-06 | 8.17e-08 | 9.46e-08 | 1.29e-08 | 0.93 | 0.93 |
| Toluene | 8.38e-02 | 8.60e-06 | 2.77e-06 | 2.78e-06 | 1.37e-08 | 0.20 | 0.20 |
| Xylene | 7.40e-02 | 8.50e-06 | 2.75e-06 | 2.76e-06 | 1.36e-08 | 0.20 | 0.20 |

* $K_{wa}$ is based on $D_{wat}$ values updated since the March 6, 1997 IOM.